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Exploring the Relationship Between Various Testing Methods and Heart Rate During Judo Matches

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Abstract

Objective: To investigate the relationship between different testing methods and heart rate in judo athletes During Judo Matches.

Methods: Eight lightweight (<66 kg and <73 kg) University Division I judoka were tested (mean age: 21±1.06 years; height: 171±6.84 cm; weight: 69±5.59 kg; years of training: 10±2 years). Each athlete performed a 10-second continuous over-the-shoulder wrestling attack, a crucifixion run, a 150-meter speed run, and a 90-second attack test to compare anaerobic heart rate responses during judo-specific competition training. Data were analyzed using Pearson's cumulative correlation and repeated measures ANOVA.

Results: The 150m sprint was significantly correlated with the 90-second judo test (r^2=0.5). The coordination test showed a moderate correlation with the judo-specific test (r^2=0.3). The judo UKSN was strongly correlated with the coordination test (r^2=0.7) but not with the 3m cross run (r^2=0.1).

Conclusion: The four-limit analysis model highlights the strengths and weaknesses of athletes' basic and specialized abilities. Poor basic abilities in judo can impact performance in specialized sports. Future training should focus on strengthening identified weaknesses using the four-limit analysis model to predict basic abilities during the preparatory training period.

Keywords: Judo training, 3m cross running, coordination

Résumé de l'étude

Objectif : Étudier la relation entre les différentes méthodes de test et la fréquence cardiaque chez les athlètes de judo lors des matchs de judo.

Méthodes : Huit judokas légers (<66 kg et <73 kg) de Division universitaire I ont été testés (âge moyen : 21 ± 1,06 ans ; taille : 171 ± 6,84 cm ; poids : 69 ± 5,59 kg ; années d'entraînement : 10 ± 2 ans).). Chaque athlète a effectué une attaque continue de lutte par-dessus l'épaule de 10 secondes, une course de crucifixion, une course de vitesse de 150 mètres et un test d'attaque de 90 secondes pour comparer les réponses de la fréquence cardiaque anaérobie au cours d'un entraînement de compétition spécifique au judo. Les données ont été analysées à l'aide de la corrélation cumulative de Pearson et de l'ANOVA à mesures répétées.

Résultats : Le sprint de 150 m était significativement corrélé au test de judo de 90 secondes (r^2=0,5). Le test de coordination a montré une corrélation modérée avec le test spécifique au judo (r^2=0,3). L'UKSN de judo était fortement corrélé au test de coordination (r^2=0,7) mais pas à la course croisée de 3 m (r^2=0,1).

Conclusion : Le modèle d'analyse à quatre limites met en évidence les forces et les faiblesses des capacités de base et spécialisées des athlètes. De mauvaises capacités de base en judo peuvent avoir un impact sur les performances dans les sports spécialisés. La formation future devrait se concentrer sur le renforcement des faiblesses identifiées en utilisant le modèle d'analyse à quatre limites pour prédire les capacités de base au cours de la période de formation préparatoire.

Mots-clés : Entraînement de judo, course cross 3m, coordination

Chapter 01 :

Introduction

I. Background of the Study

Judo, a dynamic martial art with a rich history, was founded in 1882 by Jigoro Kano in Japan. Rooted in the traditions of Japanese jujutsu, judo emphasizes grappling techniques to overcome an opponent, focusing on throws, pins, and joint locks (Tokuyama, 1997). Its competitive debut at the 1932 Los Angeles Olympics, albeit as a demonstration, sparked global interest (Morgan & KIyonaga, 1997). Officially recognized as a men's Olympic sport in 1964, judo witnessed the inclusion of women's competition in 1992 (Kano, 1992). Today, under the governance of the International Judo Federation (IJF) with over 150 member nations, judo has become a widely practiced and cherished sport.

The international landscape of judo has undergone a fascinating shift. While initially dominated by Asian countries, Europe has seen a surge in participation, even surpassing Asia's judo population (IJF, 2023). This widespread growth has fueled rapid development and progress in judo techniques and training methodologies. Optimizing athletic performance for success in the international arena has become a central focus, prompting the integration of modern training science and sports science into judo training regimens (Yang et al., 2018).

The essence of judo lies in its dynamic nature. As Wang (1994) aptly describes, it is an "open-ended sport" where victory can be achieved through throws, pins, or grappling techniques to subdue the opponent. A typical judo contest lasts five minutes, characterized by a flurry of explosive movements - grabbing, transitioning, maneuvering, and executing throws - all occurring at lightning speed (Kano, 1992). This intense physical confrontation translates to high physiological demands on both judoka (judo practitioners). The constant exertion, explosive throws, and grappling maneuvers place significant stress on the athletes' cardiovascular, respiratory, and muscular systems.

Understanding these physiological demands is crucial for designing effective training programs. This study delves into the critical role of anaerobic capacity in judo performance. By investigating the relationship between various testing methods and judo-specific anaerobic capacity, we aim to provide valuable insights for coaches and athletes to optimize training strategies and maximize competitive success.

II. Motivation

Judo is a sport of waiting for the enemy to move or changing movements quickly to win. In a fight, one must be able to respond to the opponent's attack, change the direction of the body or part of the limbs quickly, keep the balance of the body during the movement, and make counter-falls or break the opponent's center of gravity in order to defend or follow up the attack. Judo has evolved into a "short time, high intensity" sport (Liao, J.K. & Hsu, J.Y., 2008), and in 2008 the International Judo Federation (I.J.F.) changed the rules of judo competition in order to make the sport more exciting, exciting, and fair. The I.J.F. has eliminated the original score (Koga) in order to increase the intensity of the competition, and t h e score will be determined by the next highest valid score (Yoko). The final decision of the I.J.F is to try out the new rules for three years, from 2013 to 2016, and to change the judging rules.

From the Judo movement characteristics, Judo athletes need to constantly repeat and high intensity short time load exercise performance, its energy metabolism is anaerobic non-lactic acid (ATP-CP) into the use of anaerobic lactic acid (or anaerobic glycolytic system) system, in the course of the competition, there will be many repetitive application of movements such as wrestling, movement, mutual antagonistic pulling and pressure and other movements of the combination of movements and due to the ground and clothing limitations, accompanied by very short rest. The combination of these movements is also accompanied by very short breaks due to the limitations of the venue and uniforms. Therefore, it is very important to improve the lactate metabolism and aerobic capacity of judo athletes.

Athletes often exceed the anaerobic threshold intensity in power output, which results in a high concentration of blood lactate, and if a large amount of lactate builds up early in a competition, fatigue will easily occur in the physiological state, thus affecting the execution of the athlete's movements and performance (Liu, 2007). Based on the above mentioned competition methods and rules, it is found that basic skills such as speed and endurance are very important to judo Athlete, therefore, this study aims to investigate the effects of basic skills on judo specialties.

III: Purpose of the Study

This study aimed to investigate the correlation between heart rate and technical performance of judo lightweight athletes through the relationship between heart rate and technical performance

of judo athletes with different testing methods. The objectives of this study are summarized as follows:

- To investigate the effects of coordination and anaerobic loading on Judo sparring and basic techniques. To explore the effects of basic and specialized tests on individual performance.

IV: Explanation of Terms

The important terms covered in this study are described as follows:

1) Judo Specialized Ability (Uchi-Komi)

Judo Technique Training, translated into Chinese as Combo Technique: Judo technique practiced through repetitive, systematic and time-consuming direct collision drills.

2) Specialized Aptitude Test (Seoi-Nage)

The term "over-the-shoulder" is used in judo, and this study does not require the opponent to be thrown down, as the over-the-shoulder throw is a judo technique in which the opponent is not thrown down by the shoulder.

3) Heart rate

Heart rate is the frequency of heartbeats per unit of time. In this study, the heart rate is the value measured by the heart rate meter (i-Heart 1.0) in the subject's test.

4) Cross running

In this study, participants completed a distance of 3 m and three repetitions of front-back-left and right-left at the highest speed set by the experimental site.

5) 150 m run

In this study, the distance of 150 m was determined by the individual's fastest speed for 2 times in the experimental field.

6) Coordinated Testing

In this study, the test was conducted in a 30 m long and 30 m wide field. The participants started from the starting point, ran forward topass the obstacles as fast as possible, and completed the three kinds of obstacle running in order, with a total distance of 26 m for each coordinated running group.

Chapter 02 :

Literature Discussion

Chapter introduction:

The human body has a great potential for structural and functional adaptation to physical exercises. This adaptation as a result of very special exercises aimed at improving sport-specific performance ability leads to the emergence of difficult and different training techniques. The fact that the energy system required by each sport branch is different depending on the duration and intensity of the application depends not only on the type of training but also on the effectiveness of the training programme applied. The effectiveness of the training programme requires continuous measurement and evaluation of the structural and functional properties of the body systems that are primarily required by the sport branch of interest. Measuring the contribution of different training techniques to physiological motoric characteristics and evaluating their effects on performance is very important for the development of effective exercise planning specific to the individual and branch (Güneş 2008).

Physical fitness and adaptation are necessary for an effective performance in sports. It is stated that it will be more beneficial for the physical and physiological mechanism to be both branch-specific and appropriate for the athlete in order for the athlete's performance to be at high levels and to maintain this level of performance. However, the fact that only the physical structure of the individual is at the desired level shows that high performance is not the only factor.

The main factors affecting performance are flexibility, physical strength, body composition, strength and speed, endurance, flexibility, height and weight. The technical and tactical part of the sports branch is very important for the competition. It constitutes the basic features required for a scientific study (Uzun 2018).

An area that has developed cumulatively and is constantly researched is known as training and performance development in sports. The programmes required for exercise studies that push the limits of human structure in achieving success and the necessary researches applied on these methods maintain their continuity (Karatosun 2010).

Nowadays, it is known that athletes engaged in high intensity performance sports are considered as a whole both physiologically and psychologically in terms of heredity. Sports science professionals use scientific tests, i.e. Trial and Error or observation.

The decisions seen are some of the important methods used in the preparation period of athletes for the competition. Receiving information from professional sports science people for test results about how the levels that athletes need to reach or want to reach in terms of performance should be formed shows that both the athlete and the coach often use this situation (Uzun 2018).

Sport is defined as motoric and physical activities that are carried out individually or as a team and put forward by planning a competition; within the framework of certain rules and without any interest. In addition, sport is considered as a recreational activity to utilise free time in the most enjoyable and active way, to live healthy, to maintain physical form as well as a career choice. In addition, since sport appeals to large masses, it is defined as an activity that brings communities behind it, based on the defeat of athletes among themselves within the framework of specified rules (Özbek 2000).

An athlete is an active individual who fulfils the requirements of his/her branch within the rules, who does not give up the struggle, who is inspired by solidarity and traditional ties, who sees and performs sports as a professional job, and who experiences material and moral satisfaction. A professional athlete, on the other hand, is an active person who places the sports branch he/she performs in the focus of his/her life and aims to increase his/her performance by making plans in this direction, and knows that he/she must fully implement the programmed required by his/her branch in order to maintain this level (Yorulmazlar 2000).

1.1. Judo

Judo sport literally means JU: politeness, kindness, DO: way. In short, it means "the way of kindness". Judo is not only a physical activity but also a lifestyle (Tegner 1974). Judo is an effective defense art that everyone knows very well. At the same time, as an Olympic sport, it is the best known among the defense arts. Judo is a constantly renewed and developed sport in terms of Olympic rules. Many different technical features are applied in judo competitions in order to reach the result. Judo has the feature of being a defense sport that starts standing ready and continues on the ground (Dominy 1966).

Judo is a sport based on the principle of overcoming the opponent by using the force coming from the opposite side that individuals of all ages can do. Judo has concepts such as balance, strength, quickness, coordination and flexibility. Judo, which contributes to the personality and physical development of children, was presented to children by Unicef. In international norms,

the average age of starting Judo is 7 years and above. It is known that children who learn Judo increase their self-confidence without being aggressive and exhibit the necessary reaction with calm behaviour. Therefore, in many developed countries of the world, Judo is included in the education programmes of primary and secondary schools (Çakıroğlu et al 2013).

Judo is a complex sport with some important values that will affect the final match result. The volume and intensity of the Judo match classifies Judo as an anaerobic-aerobic sport. Since Judo is basically a branch in which athletes try to outsmart each other, Judo experts believe that special mental abilities are very important for successful Judoists (Krstulovic 2012).

Judo is one of the defence and combat sports and is one of the Olympic branches. It contains concepts such as being respectful, self-confidence of the individual, and being courteous. Physically, it is a functional sports branch that includes features such as strength, coordination, flexibility, balance and quickness. This branch is expressed as the most effective defence of the athlete with a number of techniques, without responding to the force applied by the rival athlete in terms of technical features, even using the force that will come from the rival athlete (Uzun et al 2018).

Judo is not only an elite sports branch, but it is also known to be an art that can be used during war. As the name suggests, it is one of the sports branches where fair-lplay rules should be applied. It is a sport that has more than one meaning for many people. It is a type of sport that includes concepts such as self-defence, bodybuilding programme, struggle, art, entertainment or a social activity. It is known to benefit the society in terms of health and strength and to contribute positively to the development of both moral and mental aspects as well as the character of individuals (Morpa 2007).

1.1.1. Historical Development of Judo

In our sports culture, Judo branch appears as a type of sport that is not alien to us. If we examine our sports culture; We see that Judo is a sports activity similar to wrestling sport that can be done with a dress. It is a sports branch that many Turkish states in Central Asia have recently widely preferred. This sport, which gradually spread all over the world, has become a branch that has been organised world championships especially for the last 15 years. Kurash is expressed as the ancestor of Judo sport. The Turks who lived in ancient times express the name of wrestling as washing or catching. While wrestling was done with a wrestling suit, a garment

called a jacket was removed over time in order to make the wrestling sport more difficult. It is stated that while it was done by applying oil to the naked body about 700 years ago, it was made more difficult for athletes to apply games or techniques (Şilli 2019).

The judo sport of our age was revealed by Japanese Dr Jigoro Kano. Until 1882, he received ju jutsu training as well as the training he received. Ju Jutsu sport is used by Japanese samurai and is one of the traditional fighting techniques of samurai. Its basic principle is expressed as a sports art that enables the weak to prevail over the strong. It is known that in the following periods, this sport removed some negative techniques and established the sport of judo. He gave the training of this sport in a school called Kudokan and is still known as the school where the world's best judo athletes emerged (Şilli 2019).

Our country recognised Judo sport after being included in the North Atlantic Treaty. Our officers and non-commissioned officers participated in a number of military courses in the USA in line with NATO training programmes, learned for self-defence purposes, and it is also known that they applied it in our own military training after returning to our country. It is known that Ergun Göktun, who received training in Judo in Germany, worked in many provinces to spread this sport in Turkey (Öztek 1999).

With the increasing interest and interest in judo sport, it is thought that wrong techniques are being applied and wrong working systems are being applied. This situation has been noticed by the General Directorate of Physical Education. Therefore, Judo

It was officially affiliated to the Wrestling Federation in 1964 in order to bring a certain standard to the training with Kudokan techniques (Güler 1996).

Due to the increasing interest in judo sport in our country as in the whole world, Turkey Judo Federation was established on 16 April 1966 and started to operate. In 2006, Turkey Judo Federation has taken its current form with an autonomous structure (Şilli 2019).

The first official tournament we participated in for the sport of judo was the Austrian Tournament in 1971. In 1971, the first and important organisation was the Mediterranean Games. All of our five participating athletes received medals and achieved a great success. Later, at the Barcelona Summer Olympics in 1992, Hülya Şenyurt won the bronze medal and became the first Olympic medallist of our country. Hüseyin Özkan (66kg) made our country

proud by winning the gold medal at the Sydney Summer Olympics held in 2000 and wrote his name in judo history (Şilli 2019).

1.1.2. Structure of Judo Branch and Motoric Requirements at the Time of Competition

It is stated that the basis of judo sport is to have high levels of loading in terms of violence (approximately fifteen to thirty seconds) and periods of 10 - 15 seconds as rest (Atabeyoğlu 2009).

Considering the values measured at the end of the competition (heart rate max. 92% and lactate values of 12.3 mmol/L), it is assumed that the structure is of high intensity, while high free fatty acids are found in plasma, glycerol and triglyceride data show that some of the judo competitions consist of anaerobic exercises. The prolonged warm-up period on the competition day and the fact that there are many competitions throughout the day are known as the main reason why competitions use aerobic and anaerobic energy systems at the same time (Artioli et al 2005).

1.2. Anaerobic Energy System

Anaerobic power: It is the organism's use of the phosphogen energy system to meet the energy needed in the first 8-10 seconds of high effort. In today's sports branches where competition is increasing, anaerobic power that occurs as a result of explosive and very fast activities varies significantly (Eniseler 2010).

Anaerobic power: It is the system in which a large amount of the energy needed is consumed in loads lasting approximately 2 to 2.5 minutes in which the individual consumes excessive effort. The reason affecting the formation of anaerobic energy is thought to be the increase in anaerobic enzyme movements when the maximum load lasts at least 30 seconds (Eniseler 2010).

1.3. Training

As the studies carried out in order to increase the efficiency of the organism are called "training" (Muratlı and Sevim 1993), it can be considered as the process of motor, technical, tactical, psychological and mental preparation of athletes through training (Renklibay 1994).

The common purpose of training in our age is expressed as organised training aiming to rapidly increase the physical, psychological, mental or mechanical efficiency of the individual (Sevim 1991). In order to remain efficient and healthy, every organism must be in balance with its surroundings, demands, necessary equipment and characteristics. This constant balance stability is possible through the operation of many functions in the organism. To be able to get efficiency with the equipment and features of the organism during exercise

for a constant state of equilibrium. The increased performance efficiency during training depends on the intensity of the repeated stimulus. The stimulus can be of various types and intensities and produces an adaptive effect in the organism. In this case, sport training is a "movement stimulus directed at a specific efficiency target". is expressed as "movement". Because movement shapes the organism better than all stimuli (Candan and Dündar 1996).

Sport sciences have analysed training under two headings: mental and physical training. Physical training is analysed in two sections as technical and conditioning training (Sevim 1991, Candan and Dündar 1996).

Mental training: It is defined as learning or realising the flow of movement by visualising the planned exercise intensely in the mind without actually doing an exercise. It has been found that mental training releases even reserve energy stores and increases motoric power by 20-25% (Gündüz 1993).

Physical training: In order to increase the efficiency of the organism, it is the application of a set of loads that are specially prepared for the individual or the team, with specific targets, planned and applied at intervals. Physical training has positive effects on skeletal muscles and cardiovascular system (Candan and Dündar 1996).

Technical training: It is called all of the physical activities that are performed at certain intervals in order to use the power efficiency more economically and whose aim is to improve the cooperation between the organs and that do not cause changes in the structure of the organism (Candan and Dündar 1996).

1.3.1. Characteristics of Physical Training

- **Frequency of training**

In a one-week training programme, it gives the training units and the temporal relationship of the loads and rests covered by these training units. It depends on training intensity and duration (Çalışkan 2013).

- **Training duration**

A training programme is known as the phase of loading in it and the duration of the collective effect of the loads on the organism. In other words, training units depend on the duration of the loads in it (Çalışkan 2013).

- **Intensity of training**

It is the degree of concentration of the work done in a training. The intensity, duration and frequency of the load determine the intensity of the training (Çalışkan 2013).

1.4. Energy Systems

1.4.1. Aerobic Energy System

The most effort is exerted in the performance of a sport. It is known as the amount of oxygen used during the production of energy by the organism. VO2max (Maximum Energy Capacity) is necessary for the elite level athlete to reach the level of his/her own team. In addition, it differs according to the position of the athlete and other athletes playing in the same team. All these situations are expressed as aerobic power (Eniseler 2010).

Energy is the necessary factor in the movement of the muscular system of the organism. The capacity to transfer the oxygen to the muscle masses of the organism to be used to create the energy needed during training is referred to as aerobic capacity (Eniseler 2010).

Light tempo runs at an intensity where the lactic acid level in the blood of the organism is at 2 mmol levels are called "aerobic threshold". It is also known that such runs are used in the stages of warming up, cooling down and recovery (Eniseler 2010).

1.5. Motor Development

The growth of body structures and the ability of the organism to move properly in accordance with the development of organs is called motor development. With motor development, it is seen that the person has an experience against movements. Strength, speed, endurance and flexibility with regular training programme

Such sports-motoric characteristics can be developed and these characteristics can bring the body to the desired level (Oxendine 1982).

Physical growth and motor development are related to each other and they develop and progress together. Human movements are divided into two as reflexive movements and conscious movements. The main aim of the motor development process is to bring the movements to a voluntary and purposeful level. Behind most of the movements performed physically, there are general characteristics of the physical structure. For example, heredity and muscle type are very important for speed. The harmony and development of the nerve-muscle system also affects the motor development area. Development is the acquisition of biological function as a result of changes in the structural composition of cells and tissues (Docherty 2007).

1.5.1. Importance of Motor Development

The importance of motor development phenomenon has been increasing rapidly since the birth of human beings. For this reason, the number of researches on the subject is constantly increasing. It is stated that the motor skills of individuals do not occur spontaneously and that studies require expertise for this. It is thought that motor development will be useful in recognising the individual (child) scientifically, providing information about when, how and in what way the movements should be taught, being aware of the differences in terms of gender and at the same time understanding that personal differences are also important (Koç and Şahin 2005).

1.5.2. Basic Motoric Characteristics

Motoric characteristics develop in a natural change process of the person and are used in daily life even without any training. The development of motoric characteristics cannot be considered separately from the movements applied in training. Therefore, basic motoric abilities can only be brought to the desired level by training (Sevim 1997).

1) Strength
2) Speed
3) Endurance
4) Flexibility (Mobility)
5) Coordination (Skill)

Basic motoric capacities are known as inherited characteristics that are inherited at birth. These are the basis of human life and movements. It can be brought to the desired level with appropriate stimuli. Sports exercises are essential for proper and systematic development (Pelayo et al 1997).

1.6. Force

In sports science, the expression of strength has been expressed and classified in many different areas and in different ways. Many sports and scientists have made different definitions on this subject. Strength is known as the ability to resist a certain resistance (Özer 1983).

Strength can also be defined as the ability to respond to both internal and external resistance with nerve muscle ability. The highest force produced by the athlete depends on the biomechanical properties of the movement and the contraction size of the relevant muscle groups (Zatsiorsky et al 2020).

The ability of the muscle to contract against a certain resistance and the ability of the contracted muscle to maintain its own contractility is called strength (Zorba 2019)

1.6.1. Force Types

- ✓ Strength in general terms: It is defined as the sum of the strength of all muscular properties of the organism in a general sense for any sport branch or a field (Sevim 1997).
- ✓ Special strength: It is defined as the strength used in a way specific to the movements required by the sport type (Demirci 2007).
- ✓ Quick strength: It is the ability to overcome a certain resistance quickly (Özer 1983).
- ✓ Continuity in Strength: It is the ability to continue exercises for a long time against fatigue (Özer 1983).

- ✓ Maximal Strength: It is the greatest power obtained instantaneously as a result of muscle contraction (Özer 1983).
- ✓ Static Force: It is known as the type of contraction in which the muscle length remains constant during contraction and there is no change in the length of the muscle (Sevim 1997).
- ✓ Dynamic Force: It is known as the shortening that occurs in the length of the muscle as a result of the contraction of the muscle at the moment of movement (Sevim 1997).

1.7. Speed

It can be expressed as performing a movement or movements at the highest possible speed or moving oneself from one place to another at the highest speed (Sevim 2002).

The important point in speed is to react quickly and instantly to the stimulus coming from outside. This is also important for speed ability (Muratlı and Sevim 1993).

In physiological terms, the ability of the muscular system to perform movements in the least time depending on the mobility basis of the nervous system is called speed. In training science, strength is also known as moving one's body at a high speed with the help of a part or all of the body (Açıkada et al 1991, Akkuş 2008).

Speed is divided into two as general and special speed. The rapid response to an external stimulus without discrimination is called general speed. The reaction given to a stimulus for a purpose is known as special speed. This type of speed differs according to sports branches. Generally, it cannot be transferred to other sports. Speed is a feature that depends on genetic factors and genetic structure is the general determinant of speed (Bompa 2003).

1.8. Endurance

Endurance is the power of the athlete to withstand physical and physiological fatigue for a long time. In other words, it is the ability of the organism to resist against ongoing sportive exercises and to sustain high intensity loads for a long time (Çimen 1994).

Endurance is analysed in two ways according to the type of sport:

1. General endurance: It is the general feature that athletes should have in all sports branches.

2. Special Endurance: It is called the feature that is suitable for the structure of the branch and should be (Sevim 1997).

Endurance is divided into two in terms of energy formation;

Aerobic endurance: It is known as the body's response to prolonged fatigue in an oxygenated environment. In general, aerobic endurance in low-intensity, long-term exercises and activities; It is called the entire system of the respiratory, circulatory and nervous system involved in the organism's intake and use of oxygen, which can resist fatigue with long-term effort (Toprak 2019).

The work done and the energy expended must be in balance. In general, it is the endurance of the organism in an environment with sufficient oxygen without oxygen borrowing. It is known that as the time is prolonged in continuous training for more than three minutes, it is known that the aerobic system is completely switched to the aerobic system. The maximal amount of oxygen that a person can use during a maximal load is called aerobic endurance (Sevim 1997).

Aerobic endurance is divided into three;

- ✓ Short Duration Aerobic Endurance: Exercises between 8-10 minutes
- ✓ Moderate Aerobic Endurance: 10-30 minutes of exercise
- ✓ Long-term Aerobic Endurance: Exercises between 30-120 minutes

Anaerobic Endurance: It is defined as the ability to perform any sportive exercise from the energy stores in the organism without the need for oxygen and to continue the exercise at maximal or very high loads or overloads in terms of dynamism and speed. In general, anaerobic endurance has a maximum temporal load of 180 seconds. In sports branches and competitions that require anaerobic energy, this type of endurance is especially needed at certain temporal intervals (Sevim 1997).

Anaerobic endurance is divided into three:

- Short duration anaerobic endurance: Exercises lasting 20 to 25 seconds. For example, 100 and 200 metre races.
- Medium Duration Anaerobic Endurance: Exercises lasting from 20-25 seconds to 60 seconds. For example 200-400 m races.

- Long-Term Anaerobic Endurance: Exercises lasting from 60 s to 120 s, maximum 180s. Example 400-800 m races (Dündar 1998).

1.9. Flexibility

Flexibility is the name given to the functional properties of the muscles and joints that perform the movements of the parts of the body. Inadequate flexibility makes it difficult to learn new and different movements, increases the athlete's risk of injury, negatively affects the development of strength, speed and coordination, prevents the quality of movements and negatively affects performance (Zorba 1999).

If the elastic structure of the muscle is not at the expected level, it causes limitations in movement frequency and such a problem that is expected to occur negatively affects the harmony of nerve-muscle coordination and causes low efficiency in terms of movement. However, the desired level of joint flexibility will allow the movement to be performed at large angles and will contribute to the movement to be performed more efficiently (Duyul Albay 2005).

1.10. Coordination (Skill)

There are different information about the definition of coordination in the sources. According to Yıldız (2007), the ability to perform complex and difficult movements in a short time in different environments in accordance with the purpose is called skill. Coordination skill acts depending on other motoric characteristics. It is affected by all motoric characteristics (Bompa 2003).

Sevim (2002) defines skill as the ability to perform voluntary and reflex movements in a harmonious system in accordance with the purpose; according to Bompa (2003), skill is defined as the ability to perform different, unusual and different movements without difficulty and to complete them in accordance with the purpose.

1.10.1. Types of Coordination

- ✓ General Coordination: It is the general body skill that is valid for every sport branch.
- ✓ Special Coordination: It is the coordination of technical, tactical and similar movements for the applied sport branch, which includes the characteristics of that sport branch. The

main purpose of coordinative skills is to correct movements and to provide the ability to make special decisions on certain issues (Sevim 1997). Different training methods are used for a performance level desired to be achieved in the athlete. Plyometric training is one of these special exercises (Sayar 2018).

1.11. Plyometric

Chu and Plummer (1984) define the form of exercise that contributes to the muscle to reach the highest level of strength it can reach in the shortest time as "plyometric". These and similar exercise types include some kind of jumping forms. Different types of exercises can also incorporate these modes. Plyometric exercises use the force of gravity to store energy (potential energy) in the muscles of the organism. This energy, which is used in the immediate reaction, will produce kinetic energy with the ability of the muscles to stretch (Asmussen and Bonde-Petersen 1974).

1.11.1. Plyometric Training

Plyometric training is known as a training method that develops explosive strength and allows quick and effective use of muscle strength (Aykora and Dönmez 2017). Plyometric exercise is expressed as an explosive concentric contraction that occurs after an eccentric contraction that contains a quick and powerful serial movement form (Çakır 2016).

At the moment of plyometric training, a great tension occurs in the relevant muscle or muscle groups. This tension automatically causes an isotonic (concentric) contraction, and when a voluntary contraction order is transmitted to the same muscle or muscle group at this time, the muscle contracts with all its units and strength, creating a force (Uluçay 2009).

The aim is to ensure that the force can be exerted vigorously in a short time by concentric contraction, which is another type of contraction after the muscle has contracted eccentrically with more elastic force. In this way, muscle contraction at a high speed is the elastic force generated by the resistance of the nervous muscular system against resistance. This exercise is in the form of a negative and positive directional strength training and it is thought that it aims to spend the force and kinetic energy as quickly and beneficially as possible and contributes to the development of instantaneous jumping power (Brown et al 1986). Plyometric exercises cause the elastic properties of muscle fibres and connective tissues to be utilised. It is stated that it contributes to collect the energy formed during the deceleration and contraction of the muscle

tissue and to release that energy at the moment of acceleration and contraction (Kalyoncu et al 2005). After a fall from a high place to the ground, the muscles that will work as agonists are stretched and at this point, the stretching reflex is initiated through the muscle spindles. The stretching reflex is transmitted to inactive muscle fibres as arousal and increased, and the subsequent contraction is higher and faster. It is stated that this is the basic working principle of the muscle tissues of plyometric exercises (Kalyoncu et al 2005).

2-1. Exercise Load Heart Rate

How to utilize different types of training intensity for exercise, the best effect on health, has alwaysbeenthe focus of everysports participant; different sports training methods, with different sports training effects low intensity and long duration of exercise training, the best effect on cardiorespiratory function training. Therefore, how to determine the intensity of exercise is very important. Since heart rate is the most easily obtained physiological parameter, it is convenient to use heart rate as an indicator of exercise load, and Böhmer (1975) pointed out that the speed of heart rate increase during exercise and the rate at the end of exercise can indicate the cardiorespiratory fitness. The number of heartbeats is determined by the interaction of the sympathetic and parasympathetic nervous systems, and can usually be determined by instrumentation or by hand. It is the most direct response of human physiology to external or internal changes. Besides assessing pathologic diseases, the heart rate can also be used to observe the intensity and recovery from exercise loads. The instability of the heart rate, especially during exercise, is most obvious.

Wagner and Housh (1993) proposed the concept of physical working capacity at the heart rate threshold (PWCHRT), which states that the heart rate may stabilize only during low-intensity exercise. Arts and Kuipers (1994) concluded that changes in heart rate can reflect changes in oxygen intake and exercise intensity, regardless of age, type of exercise, subject differences, and the presence or absence of a physical working capacity at the heart rate threshold.

Aerobic or anaerobic exercise and pre-exercise to intra-exercise measurements are applicable, i.e. exercise intensity can be defined in terms of percentage of maxim2mua m heart rate and percentage of · VO . This means that exercise intensity can be defined by the percentage of maximum heart rate and the percentage of · VO. Heart rate is a measure of energy.

As the heart rate increases, so does the oxygen intake. Threshold heart rate and aerobic endurance are the necessary basis for all kinds of sports, regardless of any sports athletes should have good aerobic endurance. Athletes in all sports should have good aerobic endurance so that their bodies can quickly recover the anaerobic non-lactic acid system in a short period of time in order to cope with long-duration competitions.

Gappmaier's (2002) findings suggest that the autonomic nervous system and psychomotor aging are related to heart rate variability. There are a number of factors that can affect heart rate, and heart rate varies with age, temperature, and neurological condition. Changes in System, Mood, Exercise Time, Exercise Intensity, etc. Wood, Hondzinski, & Lee 2003

In the published experimental report, it is claimed that heart rate is mainly affected by the interaction between sympathetic and parasympathetic nerves. When resting quietly, parasympathetic nerves increase and heart rate stabilizes; during low-intensity exercise, parasympathetic nerves drive down the heart rate and heart rate rises; and when the intensity of exercise is increased, sympathetic nerves drive the heart rate to increase. Achten and Jeukendrup (2003) suggest that there are many factors that affect heart rate, including environmental factors such as humidity, noise, etc., which can increase heart rate, and that heart rate can also increase significantly when physical conditions are poor.

However, it has been shown that heart rate increases with exercise intensity during progressive loading, showing a nearly covariate relationship with oxygen uptake. Therefore, heart rate can be used as a simple physiological indicator during non-maximal effort exercise. According to a study conducted by Yushi Wang in 2 0 0 6 , heart rate during exercise is affected by a number of factors. Heart rate is susceptible to changes in cardiovascular circulation and other external factors during exercise. In a study on the relationship between attentional focus, performance, and heart rate variability during shooting competitions, Chung-Min Hung (2011) suggested that the relationship between low-frequency and high-frequency heart rate variability was more important than the relationship between low-frequency and high- frequency heart rate variability. In the study of "the relationship between attentional focus and athletic performance and heart rate variability

during shooting competitions", Hong Tsung-Min (2011) suggested that there was no interaction or main effect between the type of attention adopted by the athletes and the context in the low and high frequency.

According to the above study, heart rate and oxygen intake are highly correlated, which shows that it is feasible to use heart rate to set the exercise intensity for cardiorespiratory endurance assessment or cardiorespiratory endurance training.

Table 01: Comparison of Heart Rate Percentage by Exercise Intensity (Hollmann et al., 1978).

Maximum heartrate		Exercise Intensity
182-163	**(100-90%)**	**Maximum Training**
162-145	**(90-80%)**	**Anaerobic Training**
144-127	**(80-70%)**	**Aerobic-AnaerobicTraining**
126-109	**(60-50%)**	**Aerobic**
108-91	**(60-50%)**	**Moderate training**

Smekal (2001) monitored the maximum heart rate of 151 tennis Athlete in ten /50-minute matches.± 19 min-1 ; mean heart rate on defense 158 ± 16 min- 1 ; mean heart rate on offense 145 ± 16 min min- 1 . Morgans et al. (1987) studied 17 male tennis Athlete with an average age of 31 years old, who were weekly The three training sessions revealed a maximum heart rate of 187.9 ± 11.1 min-1 ;,witha mean of 154 ± 16.9 min in singles-1 and 130 ± 16.6 min in doubles-1 . In terms of percentage, singles accounted for 82% of the maximum heart rate while doubles accounted for 7 0 % ; from the above literature, it can be seen that the average heart rate of the tennis test was roughly between Hollmann et al. (1978) suggested a correlation between different heart rates and different exercise capacities between 145 - 162 min-1 anaerobic training and 163 - 182 min-1 maximal training, indicating that the current loads are in the anaerobic load. Hsiao, Wan-ru, Chen, Chia-huei, and Chang, Chia-chak (2013) The effect of walking with different loads on heart rate and energy delivery pathways in heavy weight individuals - a case study This test was performed using three different loads of 1.5 m/s, 1.6 m/s, and 1.7 m/s, with the first walking session at 1.7 m/s and the second at 1.7 m/s. The first session was performed at 1.7 m/s and the second at 1.7 m/s. The first walk was 1.7 m/s, followed by 1.5 m/s one day later.

Biological parameters were collected as lactate and heart rate respectively and the results of the study indicated that the subject's heart rate reached a maximum of 90% at a speed of 1.7m/s. The heart rate of the subjects was 1.7m/s and the heart rate was 1.7m/s. The results indicated that the subject's heart rate reached 90% of the maximum heart rate at 1.7 m/s. Hsiao, Ching-Heng, and Chang, Ka-Chak (2013). The effects of acute high- intensity interval training on heart rate and blood lactate in street dance Breaking athletes - a case study 1. During three days of high-intensity interval training, subjects showed positive adaptive responses in terms of muscular strength output and heart rate. 2. 2. Three consecutive days of acute high-intensity interval training can rapidly improve the concentration of blood lactate and lower the heart rate of the street dance and breaking athletes, and improve the endurance ability. In a study conducted by Hsiao, Chia-Huei Chen, and Chia-Tsai Chang (2011), a professional Breaking dancer who performed the same set three times, it was found that as the number of sets increased, the duration of anaerobic state also increased, and the dancer's maximal lactate value was as high as 17.53 mmol/l after three sets, and her heart rate was 190 min.-1 . This is close to the 400-meter track race loaded with an intensity of 18-25 mmol/l. The dancer's heart rate was 190 min .

The effect of jump rate. Maximum upper extremity muscle strength was measured with three specialized tests. The mean heart rate was 125± 24.7 min.-

1-1The aerobic threshold maximal and minimal heart rates were 160 min- 1

and 100 min-1 . (Li Jianyi, Zhou Delun 2003) The study used a simulation of an official volleyball match to investigate the center jump rate during the match.

It was found that during the volleyball matches, the heart rate of different Athlete in different roles reached a significant difference. ($p<.05$). Second, heart rate was significantly higher in the front row than in the back row ($p<.05$); Athlete in different roles had significantly higher heart rates in the front and back rows ($p<.05$).

The average heart rate of all rows was significantly different ($p<.05$). Thirdly, the number of heartbeats in the 111~130 heartbeats per minute interval was much higher for the freestylers than for the other Athlete ($p<.05$); the number of heartbeats in the 131~150 heartbeats per minute interval for the fast break Athlete was lower than for the other Athlete ($p<.05$); the number of heartbeats in the 151~170 heartbeats per minute interval for the main break Athlete

was higher than that for the other Athlete ($p<.05$); and the number of heartbeats in the 131 ~150 heartbeat interval was the most frequent heartbeat interval for all Athlete ($p<.05$). The heart rate in the ~150 beats/min interval was the most frequent heart rate interval for all athletes ($p<.05$). Wan-Chen Lee, Yue-Qi Wang, and Chia- Tsai Chang (2013) investigated the effect of Taekwondo training modules on threshold heart rate as a result of changes in heart rate with different loading patterns. The mean heart rate of the loads i n t h e basic warm- up (A) and specialized training (C) was 141±14 and 134±10 for boys, with a difference of -7±4 min-1 , and 148±15 and 149±13 for girls, with a difference of 1±2 min-1 The heart rate of the subjects in the basic warm- up reached 83% (for boys) and 87% (for girls) of the threshold heart rate, while in the specialized warm-up, it reached 84% and 85%, respectively. Therefore, it is recommended to adjust the ratio of sets and rest intervals during the warm-up to avoid fatigue build-up, which may affect the performance of the next module. Chun-Guei Wang and Rui-Hsing Lin (2010) studied the cardiorespiratory fitness of men's badminton singles Athlete by using heart rate as an indicator and examined the correlation between winners and losers of badminton singles matches, the number of sets, and the duration of the match. The results of the study showed that the heart rate of men's badminton singles matches was not significantly affected by the number of games won and lost, while the number of innings won and lost had a significant effect on the heart rate. There was no significant effect of win/loss on heart rate, whereas there was a significant effect of different sets on heart rate, and a significant effect of different periods on heart rate. Good badminton Athlete have a maximum heart rate of up to 205 beats per minute (bpm) and a mean heart rate of around 186 bpm during a singles match (Liu, 1999). Hong and Tong (2000) and Liddle et al. (1996) f o u n d that heart rates during singles matches averaged between 175-189 beats per minute (HRmax). HRmax can be as high as 186±20 min per minute.-1 Heart rate monitoring has attracted many coaches, teachers, and researchers to utilize it in competitive sports because of its simplicity and practicality, and it has led to many results in monitoring the intensity of competitions and training. It has also explored a lot of results for monitoring the intensity of competition or training, which has made a great contribution to the whole field of competitive sports. When the human body carries out sports, it will gradually change the activation of the sympathetic and parasympathetic nervous system due to the increase of the intensity of the sports. At this time, the autonomic nervous system will increase the operation rate of the heart pump, which will provide the blood carrying oxygen to the active muscles, resulting in the increase of the heart rate. This results in an increase in heart rate. Therefore, the test of heart rate change can not only accurately assess the

human physiological system in the It also allows athletes to use this information to assess their own condition or as a tool for selection.

The basis for choosing an appropriate exercise program. During exercise training, athletes and coaches can follow the data on heart rate changes to correct their behavior without over-training, thus adjusting the training content and intensity of exercise to enhance the effectiveness of exercise. In order to enhance the effectiveness of the exercise, the athletes and coaches can make corrective behavior according to the data of heart rate changes.

2-2. Judo Specialized Sports Load

The sources of energy supply during exercise can generally be categorized into three main systems, which are briefly described as follows:

I. ATP-CP system:

The main system is to provide energy with short, high intensity exercise within 10 seconds. Anaerobic glycolysis system:

Exercise for 10 seconds to a few minutes

(often 1-2 minutes). Aerobic system:

This refers to the pathway of energy metabolism supplied by low- intensity, prolonged, steady exercise.

The specialized abilities of judo Athlete have been one of the areas

Of interest for many judo coaches and researchers. The main purpose of this study is to understand the specialized abilities of judo and to make specific adjustments and designs for the training of judo Athlete. Simply put, "Specialized Ability" is the ability to complete a match, or even to win a match. Judo athletes must have the ability to maintain a long duration of competition, power output, high speed of movement, and muscular system coordination (Chia-Tse Chang & Yuan-Shek Chien, 2005).

Kwok and Ting (2001) pointed out that the number of attacks and points scored by judo Athlete in the latter two minutes of the competition were generally low due to insufficient muscular

endurance. Therefore, strengthening the muscular endurance and cardiorespiratory endurance of the athletes should be the first priority. According to S.R. Chen (1998), the basic physical fitness elements for judoka include static muscular strength, explosive power, agility, endurance, balance, and flexibility. The presentation of the movement is muscle power and explosive power, the continuity of the movement is endurance, and the adjustment of the movement is balance,agility,flexibility,anddexterity.(Tabata, 1997) states that judo technique is characterized by a motor performance that includes several 15 to 30 seconds of movement loads in the

There is a 10 to 15 second rest period between each of these loads. These loads are very high intensity and the rest periods are not sufficiently long, resulting in the ATP-CP energy system not being able to recover enough to switch to the anaerobic glycolysis pathway to provide the required energy source. pathway to provide the required energy source. Judo competitors must utilize a variety of techniques such as grips, hand techniques, kicks, joint fixes, etc., which require explosive power and a fast energy supply system. Athletes who are in better shape are usually the ones who win.

Even Athlete with excellent skills can be defeated by their opponents due to fatigue.

Degoutt et al. (2003) analyzed the blood lactate concentration of judoka to increase to 12.3 mmol/l 3 minutes after the end of a match. Roquette (1992) showed that the energy of two commonly used techniques in judo, the O-soto-gari and the K-soto-gari, were operating at high levels. Both techniques have extremely high lactic acid concentrations and therefore require more anaerobic lactic acid. The better the anaerobic lactic acid, the better the competitor. Takahashi (1992) Judo is a very explosive sport and the athlete must have a well developed aerobic system in addition to an excellent anaerobic capacity. According to Chen, Ronghuang, Su, Yongyuan, and Chen (2005), the average time of a judo match is between 5-180 seconds. Each judo match usually has more intense competition and a maximum exercise load of 10-15 seconds is generated in each round of competition (Liu, 2007).

Hultman and Sahlin (1980) showed that the concentration of lactate production was related to the intensity of the exercise load, the amount of muscle mass involved and the duration of the exercise. It can be seen that as the duration of the exercise increases, the lactate maxima increase and the correlation is 0.79. Therefore, the results of both the duration of the exercise and the lactate are close to what was shown in the previous study. According to Wu & Kee (1999), a

judoka must be able to land on the opponent's back quickly, powerfully and with height in order to achieve a "one" victory (the highest score). Therefore, a judoka must have good speed, power and technique in performing technical maneuvers.

3-1. Judo Athletic Ability Diagnosis Training Application

Because Judo is not only about athletic ability, but also about balancing the output and supply of ability throughout the sport. Therefore, the specialized ability becomes the first unified ability that combines the technical performance and tactical requirements of the sport. In this study, the detection methods related to heartbeat changes are listed as follows:

Lehmann (1996), in a study of the anaerobic non-lactic energy system in judo, noted that the more repetitions an athlete completes during the test time, the better his/her endurance capacity, while the fewer repetitions he/she completes, the poorer his/her endurance capacity. The lower the number of times the athlete completes the test, the lower his/her endurance capacity. Based on the diagnostic evaluation of the lactate metabolism rate and the frequency of specialized techniques, there are four grades: excellent, good, fair, and poor. The criteria were as follows: excellent: lactate metabolic rate below 0.2 mmol/1 and technical frequency greater than 25; good: lactate metabolic rate of 0.3 mmol/1 and technical frequency equal to 24; fair: lactate metabolic rate of 0.4 mmol/1 and technical frequency equal to 24; and poor: lactate metabolic rate of 0.4 mmol/1 and technical frequency equal to 24. Good: lactate metabolic rate of 0.3 mmol/1, technical frequency equal to 24; Fair: lactate metabolic rate of 0.4 mmol/1, technical frequency between 21-23; Poor: lactate metabolic rate higher than 0.5 mmol/l, technical frequency lower than 20.

Sterkowicz (1995) and other scholars designed a three-round Special

Judo Fitness Test (SJFT) to address the specific nature of the anaerobic energy system and movements of judo. In this method, two athletes, 6 meters apart, perform the "Ippon-seo-nage" (over-the-shoulder) maneuver at maximum speed and drop each other. The test time for each round was set at 15, 30, and 30 seconds, with a 10-second break between rounds, and the number of falls and the heart rate of the tested athletes were recorded within the prescribed time, and the Judo Special Judo Fitness Index (SJFI) was calculated. The Special Judo Fitness Index (SJFI) was calculated using the following formula:

SJFT= (HR eff + HR 1 res) / sum of falls.

A significant correlation was found between the subject's Specialized Joint Fitness Index (SJFI) and the values of total work, total operating time, total distance, maximal oxygen uptake, and anaerobic threshold speed (Sterkowicz, 1995). 1995).

Lehmann's (1996) test of judo-specific ability is based on the participant's ability to apply a maximum speed change of Uchi-Komi, Seo-Nage (two consecutive movements), each test lasts about 10 seconds, with a rest period of about 30 seconds between each set, and the number of times must be recorded. Four rounds of this test were performed. 1, 3, and 5 min after the fourth test -1 , blood was collected from the earlobes of the exercisers, with a volume of about 10 μl, which could be used to record the maximal lactate value, lactate metabolism rate, the heart rate of each stage, and the heart rate at the 5th min - of the end of the exercise. The blood was collected from the earlobes of athletes with a volume of about 10 μl to record the maximum lactate value, lactate metabolic rate, heart rate at each stage, and heart rate at 5 min -1 after the end of the exercise (Yi-Hung Ma, Chiu-Cheng Lu, and Chia-Chak Chang, 2005; Bi-Yen Hou, 2006).

In 1997, Garcia et al. designed the SJFT (Specialized Judo Fitness Test) for judo training with three different movements: sit-ups, 30 cm high jumps on one foot, and back jumps and crotch drills in pairs; each movement was performed for 1 min and the number of repetitions was calculated for a total of 3 min. Each action was continued for 1 min-1 and the number of repetitions was counted for a total of 3 min-1 . The maximum heart rate (p1) and the heart rate (p2) were recorded 1 min after the end of the recordings-1 . The total number of repetitions (total reps) was calculated for a total of 3 min, The total reps, body weight (kg), and age of the athletes were substituted into the conversion formula to estimate the SJFT of the athletes. The SJFT is then used to evaluate the athlete's ability according to his/her SJFT score, which ranges from -50 to 50. The formula is converted as follows:

JMG Index = (A+B) / 2

A = [(p1 + p2) / 2] - (total reps + kg /2)

B = [K - (p1-p2)]-(total reps + kg /2)Constant K: 220-age.

Ronnie (2006) utilized a ten-station Judo ability test to examine the training effectiveness and judo-specific ability of judo Athlete. The overall test time for this test is about three minutes, which is in line with the required time for each round of a Judo competition. The test covered

five physical fitness events, including: 4 x 8m round trip, 3.3m rope climb, 10 right and left side jumps, 25 sit-ups, and 20 push-ups; and five technical events, such as 1 over-the-shoulder drop, 10 surmounts and escapes, 1 big inside cut, and 1 cross-square press escape. It is measured in terms of movement

The completion time of the athletes is used to determine the level of physical fitness of the athletes, and also to observe the athletes' performance. The degree of completeness in the execution of the movement is used to improve the technical training.

In addition, a number of studies have been conducted in China, in which seven judo sports, including the over-the-shoulder throw, inside leg, waist sweep, body throw, big outside cut, floating waist, and personal favorite technique, were measured, and the results showed that the physical and technical measurements were highly predictive of the athletes' skill performance (Chen, Y.-Y., 1996). The results showed that physical fitness and technical measures were highly predictive of athletes' skill performance (Yongyuan Chen, 1996). In 1998, Lin Wento, Wu Hecun, and Zheng Shouji took 24 male and female judo Athlete from Southeast Technical College as the research subjects, and analyzed the blood samples collected from their training and simulated competitions for blood lactate, hemoglobin, serum creatine kinase, blood urea, and blood glucose. The results of the study indicated that when the athletes participated in judo competitions, the energy supply of the human body was characterized by anaerobic metabolism as the main source of energy supply and aerobic metabolism as a supplementary source of energy supply, and that the whole process of providing energy alternated with each other to supply energy for the body to operate. Huang, Ching-Yiu (2004)

Judo tests were conducted with 7 favorite techniques, including over-the-shoulder drop, big outside cut, inside leg, body throw, sleeve fishing, waist sweep, throw, and shoulder carriage, and the test time and movements were 10 seconds, 10 sets, and 90 seconds of rest, and the number of movements was recorded in each set. The number of times that a person can lift up is more than 8 times for junior athletes, i.e. high school students; the number of times that a person can lift up is more than 9 times for intermediate athletes, i.e. the top 3 athletes in the country; the number of times that a person can lift up is more than 11 times for national athletes.

For intermediate level athletes, i.e., the top 3 in the nation in terms of national and high school strength, it is more than 9 times; for national level athletes, it can be more than 11 times; this study is based on their own compilation. The study used its own scale as the basis for training.

Liu, J.L. (2007) conducted a study on "The application and investigation of judo ability test and blood ammonia index of different energy metabolic systems", using 16 domestic tertiary athletes of different levels as the subjects. Sixteen tertiary athletes of different levels were used as subjects to test the differences and correlations between the judo tests and the blood ammonia indices of different energy metabolisms. The results showed that there was no significant difference or correlation between the anaerobic non-lactic acid judo capacity test, the anaerobic lactic acid judo capacity test, and the NH3-Index and lactate metabolism rate, technical frequency, and maximum lactate value. correlation.

In a study on the effects of 10 m round trip and cross running loads on judo endurance in eight male judo Athlete (<66 kg) aged 19-22 years old from the National University of Physical Education (NUSPE), CapaCapaCheng Lin (2010) showed that the lower the speed of the 10 m round trip and the cross running tests, the lower the blood lactate concentration, and the negative correlation between the two tests was found (r = - 0.7). 0.7) . For the 10-m r a c e and the cross race, a negative correlation (r = - 0.7) was found.

The lactate values were found to be higher in the cross-run and high lactate stacking was also observed in the 10 m switchback run.

A positive correlation (r = 0.8) was found. A positive correlation (r=0.7) was found with the results of the judo endurance test. Taken together, the results show that both the 10 m round trip and the cross run are close to the specialized Seoi-naga action load.

Chapter abstract:

From the above literature, the following points are summarized as follows Different factors and training may affect the heart rate, coaches can observe the heart rate changes, design the intensity of the training program, and find out the threshold heart rate can provide coaches with effective training methods.

Judo is a high-intensity short-term exercise program, and its main energy supply system is anaerobic non-lactic acid. Through experimentation, based on the individual's aerobic endurance capacity, we can find out the speed and heart rate when the aerobic-anaerobic threshold occurs, which is very effective as a training load intensity, and also has a significant effect on the post-exercise recovery and specialized ability.

The need for athletes to have an excellent aerobic capacity is not only important for the training itself, but also for rapid recovery during and after training.

The heart rate parameter of different tests can be used as an index of exercise intensity load to explore the correlation between judo-specific ability and cross running and 10-m sprinting. According to the above study, heart rate is highly correlated with judo, and it is feasible to use it for cardiorespiratory endurance assessment or cardiorespiratory endurance training.

Chapter 03 :

Experimental Methods

1.1 Date and Place of Experiment

This study was conducted from February 28 to April 27, 2024 for experimental data collection. The testing site was the judo and track and field gymnas University of Physical Education (IEPS).

Table 02: Basic Information of Subjects

	Mean	Deviation
Age	**20**	**1.75**
height	**175**	**6.84**
weight	**68**	**2.38**
Years of training	**10**	**2**

1.2 Experimental steps and procedures

Each participant was required to complete the Specialty and Basic Ability Tests on two consecutive days. The Specialty test was based on a simulation of an official Judo competition, and the Basic Ability test included: 10 seconds continuous shoulder drop with takedown, coordination test, 150 m run, and four tests, all of which were conducted with the athlete wearing a heart rate belt and recording his/her heart rate throughout the whole process. Details of the test are as follows:

(I) Judo 10 seconds Uchi komi-Seoi nage (T1)

For the 10-second Uchi komi-Seoi nage in this study, subjects were required to complete 3 consecutive 10-second Uchi komi-Seoi nage with a 30-second break between sets. Each set of test must be performed on a standard judo field and each set will be completed for a total of 30 seconds. During the test, the subject will be asked to perform a continuous motion attack as fast as possible, and his/her heart rate response and number of attacks will be recorded throughout the tes t (Figure 01).

	Subject 1 Subject 2 Subject 3 Subject 4 Subject 5 Subject 6 Subject 7 Subject 8		

Figure (01): the test heart rate response and number of attacks

(II) Judo Specialized Competition (T2)

In this study, the judo test was modeled after the official judo competition rule of 1 VS 1, and the heart rate of the whole test was recorded.

The heart rate and the number of attacks were taken as the basis of this study. It was considered as the basis of heart rate in this study. The heart rate of -66kg Athlete and -73kg Athlete were used as the basis for this study. A 90-second attack test is conducted by a Names-73kg athlete over a 90- second range, with a total loading time of 90 seconds, during which the subject must compete with maximum force and speed (Figure 02).

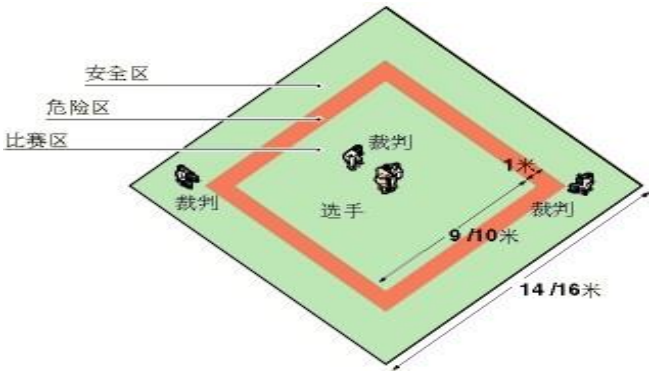

Figure (02): Schematic of a Standard Official tatami judo area

(iii) Co-ordination Test (T3)

In this study, the coordinated running test was conducted on the next day after T-2. The test was conducted in a 30-meter long and 30-meter wide field. Subjects started from the starting point and ran forward as fast as they could through the obstacles, completing the three obstacle courses in order, with a total distance of 26 meters for each group of coordinated runners. During the test, subjects were asked to run twice as fast as possible and their heart rate and seconds were recorded throughout the test (Figure 03).

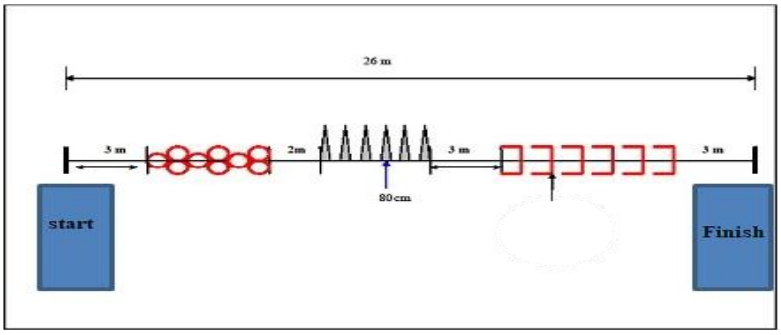

Figure (03): Coordination Test

(iv) Cross running (T4)

In this study, the CrossFit Run was administered on alternate days after the end of T1-T2. The test was conducted in a 5-meter-long and 5-meter- wide field (Figure 3 - 4). The participants started from the starting point, ran forward for 3 m and returned to the starting point, then ran left for 3 m and returned to the starting point, completing the four points of forward, left, back, and right, with a total distance of 24 m. During the test, the participants were asked to go back and forth as fast as they could and their heart rate and seconds were recorded throughout the whole test.

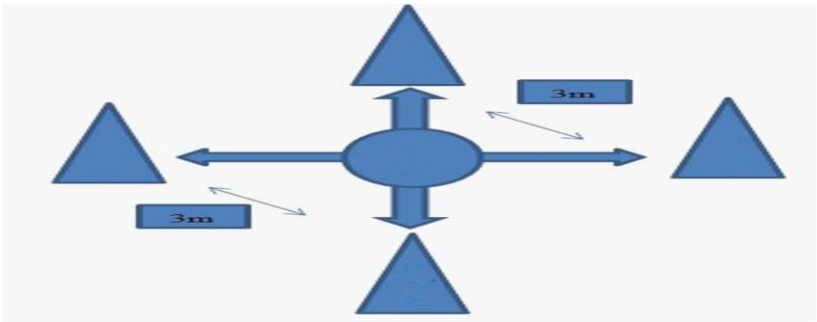

Figure (04): Schematic diagram of a 3 m cross run

(V) 150 m Sprint (T5)

The 150 m run in this study will be administered 10 minutes after the

end of T-4. The test will be conducted on a 400-meter athletic field. Subjects will start from the starting point and complete the 150 m test as fast as possible 2 times, with a rest period between sets.

The heart rate and seconds were recorded throughout the 12-minute period.

1.3 Laboratory Instruments and Equipment

1-3-1. Heart Rate (i-Heart 1.0).

Two, SEIKO Chronograph.

Angle Cone, Distance Measuring Wheel, Hula Hoop, Fence

IV. Venues (Standard Judo Field, Outdoor Track & Field)

1.4 Experimental Steps and Procedures

The procedure of this study was as follows: explanation of the experimental procedure, signing of the consent form and parental consent form, judo test, 10 seconds of continuous seoi-nage (T1), judo match (T2), coordination test (T3), cross running (T4), 150 m running (T5), and finally, heart rate data, judo attacks, heart rate, and seconds were recorded and collected (Fig. 3-5). Finally, the heart rate data, judo attack counts, heart rate and seconds measured at each test speed were recorded and collected (Figure 3-5).

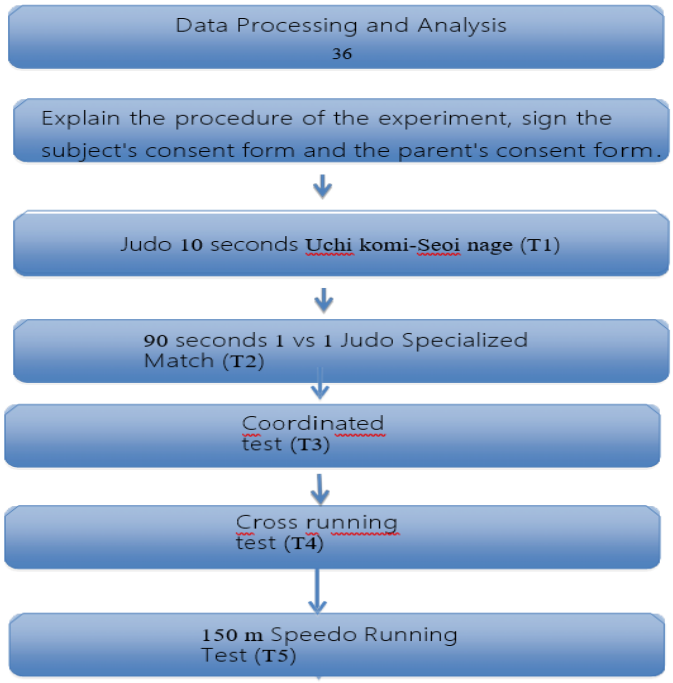

Figure (05): Flowchart of the Experiment

Chapter 04 :

Data Processing and Analysis

The descriptive statistics, mean and standard deviation were used to represent the basic information of the tested participants and the test data. Differences in heart rate of the five basic abilities were analyzed by the dependent sample T-test.

The Pearson's cumulative difference correlation analysis was used as the basis for the correlation with the ability to specialize. v. The statistically significant level of this study was set at $\alpha = .05$.

Analysis of the results of Chapter 4

1-1. Basic Physical Ability and Heart Rate for Judo Specialty Tests

Figure (06) shows the relationship between the heart rate of Uchi komi-Seoi nage (UKSN) and 3m-Cross run. The results show that the heart rate of the specialized UKSN test was between 132-169 min-1 and that of the 3m-Cross run test was between 117-153 min-1 . The two tests showed no correlation (r2 = 0.1).

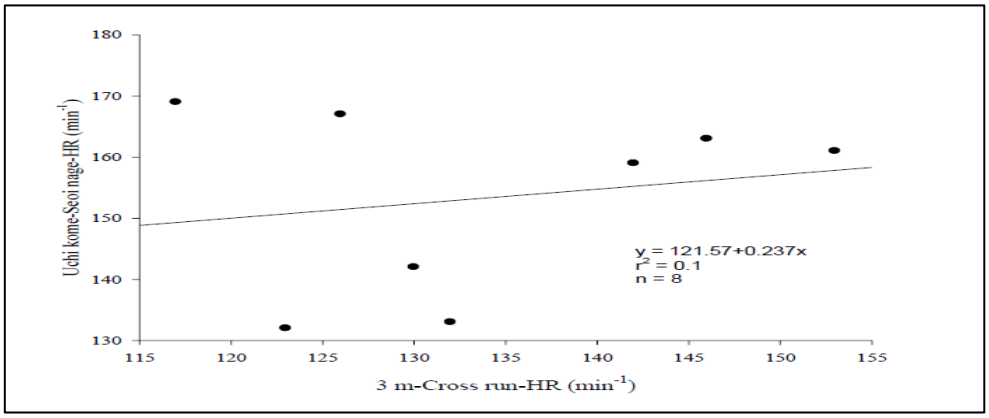

Figure (06): shows the relationship between the heart rate of Uchi komi-Seoi nage (UKSN) and 3m-Cross run

The harmonization test heart rate was shown to be in the range of 127-148 min-1 and showed a significant correlation with the UKSN test heart rate with a correlation coefficient of r2 = 0.7 (Figure 06).

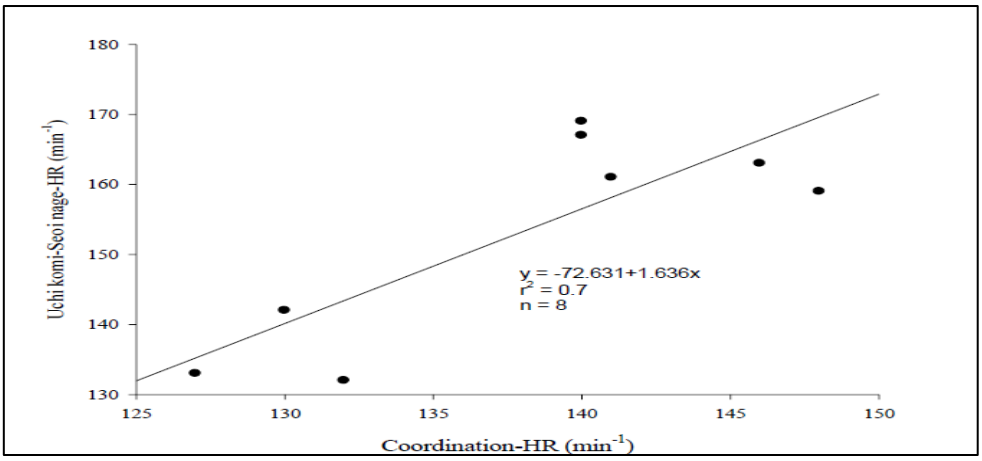

Figure (07): Analysis of t h e Relationship Between Project UKSN and Coordination.

Test Heart Rate :The anaerobic load 150 m t e s t w a s analyzed with a heart rate between 178-190 min-1 and the harmonized test with a heart rate between 127-148 min-1 . The two tests showed a positive correlation (r = 0.3) as shown in Figure 4-3. The two tests were positively correlated (r2 = 0.3) as shown in Figure 4-3.

Figure (08) shows the analysis of Judo 90s resistance and anaerobic load 150m heart rate. The results show that the maximum heart rate of 90s Judo event is 188 min-1 and the minimum is 186 min-1 . There is a significant correlation between the heart rate of 150m anaerobic load (r2 = 0.5).

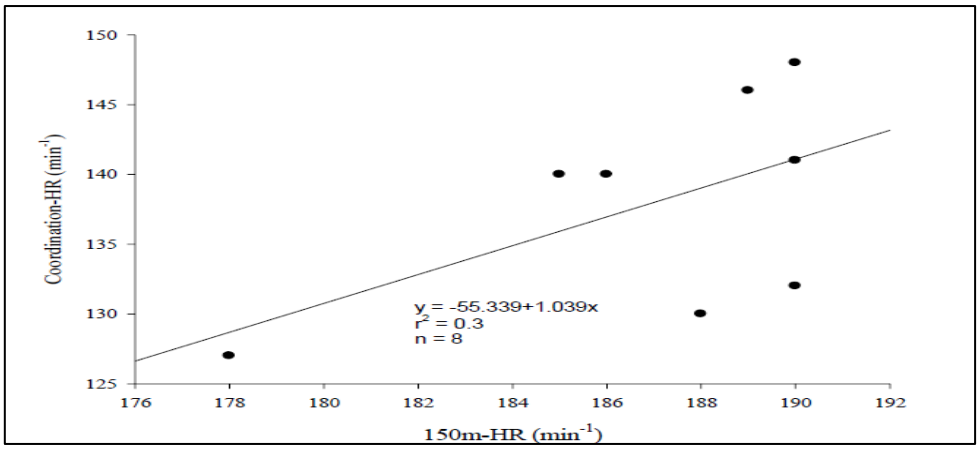

Figure (08) : Coordination of Coordination and 150 m Heart Rate Analysis

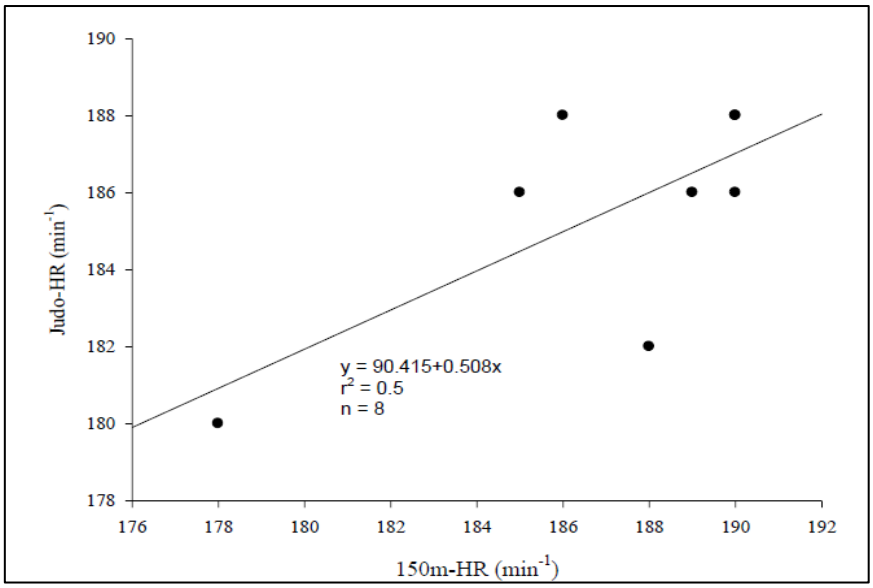

Figure (09) : Relationship between Judo 90s and 150m Heart Rate

Figure (09) shows the difference in heart rate between the basic and specialized tests. The mean heart rate of t h e 3m-Cross run was 134±12.3 min-1 , with a personal maximum of 153 min-1 . The coordinated heart rate was 138±7.6 min-1 , with personal maxima and minima of 148, 127 min-1 . The mean heart rate of the anaerobic 150m test was 187±4.1 min-1 , with a personal maximum of 190 min . The mean heart rate of the specialized tests UKSN and 90s one-on-one competition was 153±15 min , 186±1 min respectively. -1The average heart rate for the UKSN and 90s one-on-one competition was 153±15 min-1 and 186±3 min-1 . The average heart rate for the specialized test (90s) was 186±3 min . The difference between the mean heart rate of the specialized test (90s) and the anaerobic load (150 m) was 1 min-1 ($p>0.05$), while the difference between the mean heart rate of the UKSN test and the 3m-Cross run was 19 min-1 ($p<0.05$), and that of the Coordination was 15 min-1 ($p<0.05$). 0.05).

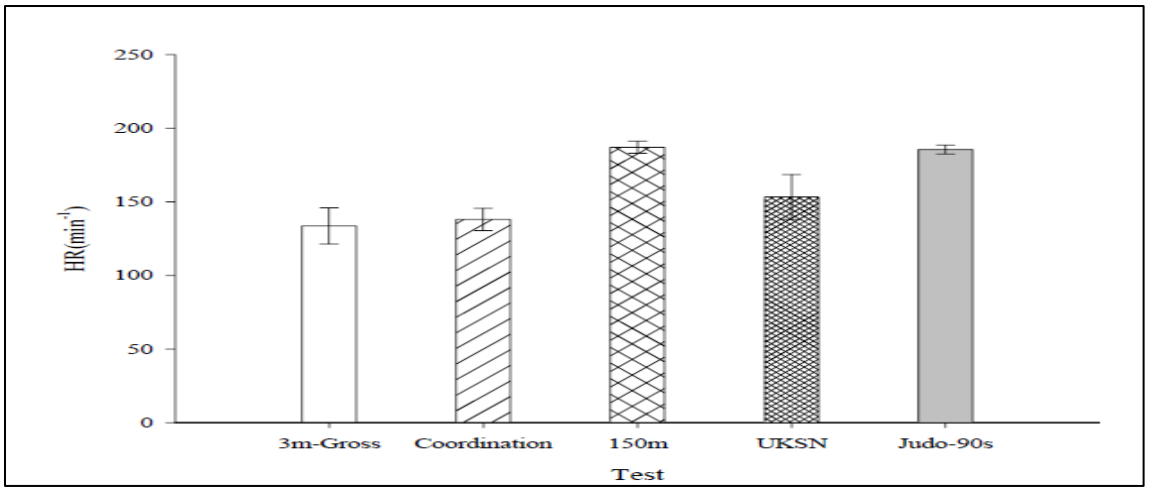

Figure (10) : Difference in Heartbeat Rates between Basic and Specialized

1-2. Analysis of Individual Basic Competencies and Specialized Performance

The study tested subjects (n = 8) in a four-quadrant analysis of basic (cross running, coordination, 150 m) and specialized UKSN, one- on-one 90s resistance:

I. Anaerobic load 150 m vs. Specialty 1 to 1 90s II. Cross running speed vs. Specialty UKSN frequency of action Coordinated Speed and UKSN Motion Frequency IV. Cross Running Speed and Coordinated Speed.

The best zone was B and the least stable zone was C for the 90s one-on- one attack frequency and anaerobic load 150 m speed (Figure 10). The best interaction was Nr. 3 and the least stable was Nr. 1 and Nr. 8 (Table 03).

Table 03: Individual Basic Competencies and Specialized Performance

Area	Subject (Nr.)	Symptoms
A	**5, 6**	**Slow at 150m, high attack rate**
B	**3**	**Fast at 150m, high attack rate**
C	**1, 8**	**Slow at 150m, low attack rate**
D	**2, 4, 7**	**Fast at 150m, low attack rate**

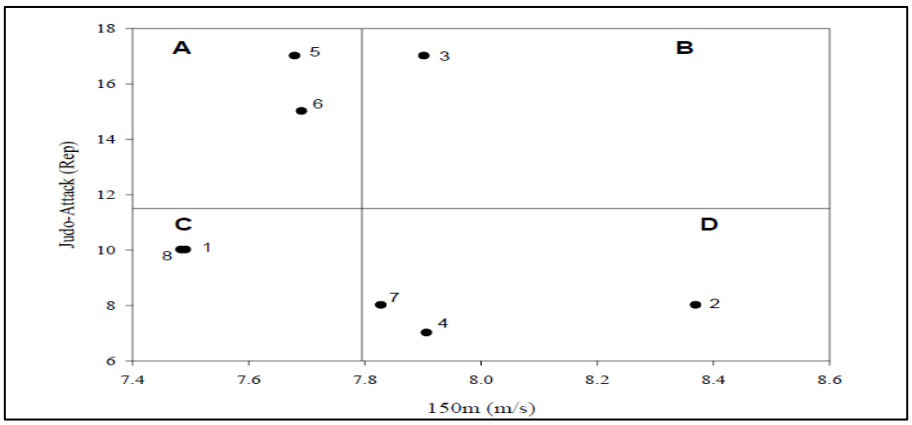

Figure (11) : Individual Specialized Judo UKSN Test Frequency and Cross Run (3 m-Cross) Velocity Analysis

The best performers in the Basic Coordination Test and Specialized UKSN Ability Analysis were Nr.1, Nr.2, and Nr.8, while the most unstable performers were Nr.4 (Table 04). The unstable respondent was Nr.4 (Table 4-3). In this interaction analysis, region A was the best interaction and region D was the most unstable quadrant (Figure 11).

Region	Subjects (Nr.)	Symptom Response
A	**1, 2, 8**	**Fast coordination speed, high UKSN operation frequency**
B	**3, 7**	**Slow coordination speed, high UKSN operation frequency**
C	**5, 6**	**Fast coordination speed, low UKSN operation frequency**
D	**4**	**Slow coordination speed, low UKSN operation frequency**

Table (04) : Interaction between Basic Coordination Test Items and UKSN Ability

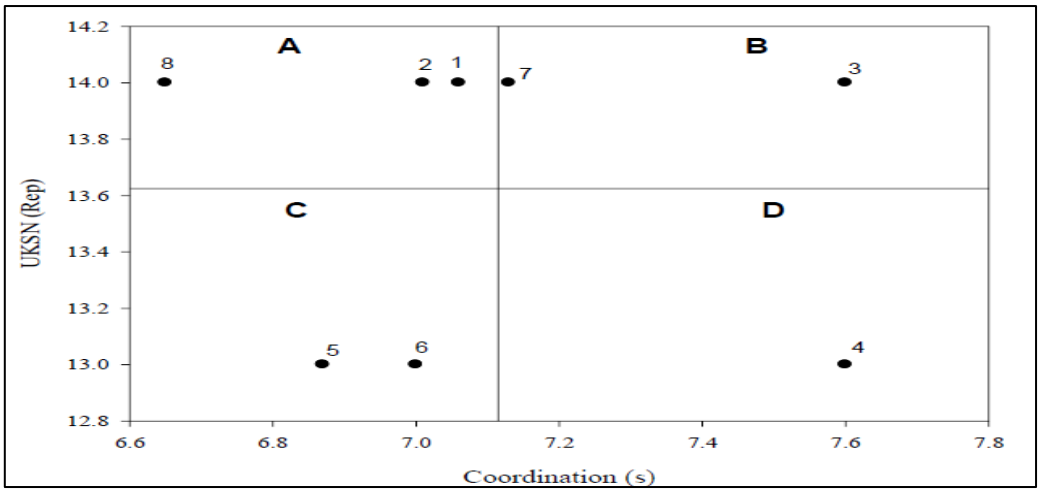

Figure (12) : Frequency and Coordination Speed Relationships in Individual Judo UKSN Tests

In the coordination test and 3m cross running ability analysis, the best subjects were Nr.2, Nr.7 and Nr.8. The best subjects were Nr.2, Nr.7, and Nr.8, while the unstable subjects were Nr.3 and Nr.5 (Table 4-4). In this interaction analysis, region C was the best interaction, while region B was the most unstable quadrant (Figure 12)

Table (05) : Interaction between coordination Test and 3m

Area	Subject (Nr.)	Symptom Response
A	4	Fast at crisscross run, slow coordination speed
B	3, 5	Slow at crisscross run, slow coordination speed
C	2, 7, 8	Fast at crisscross run, fast coordination speed
D	1, 6	Slow at crisscross run, fast coordination speed

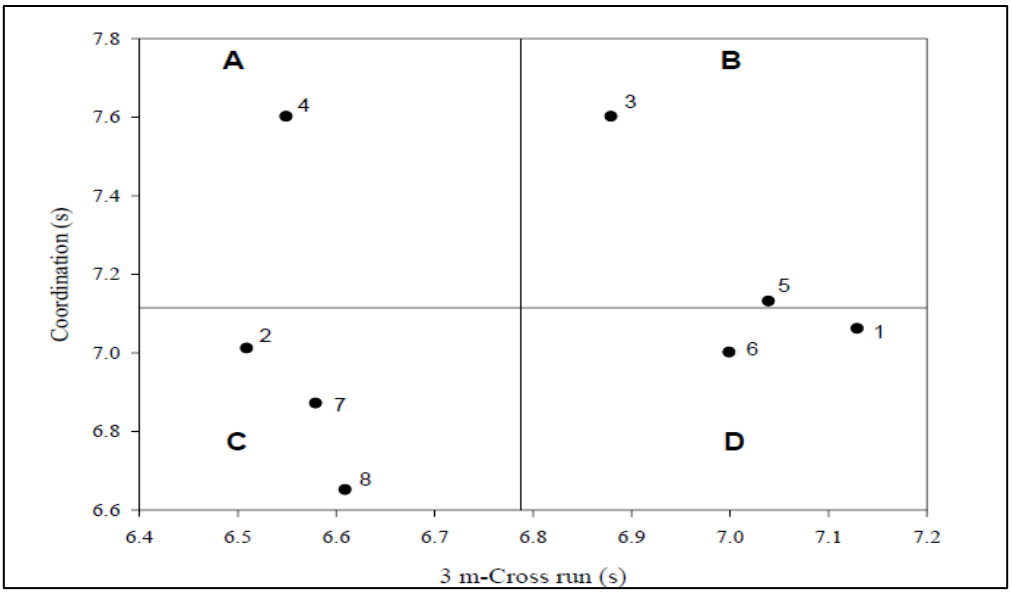

Figure (13) : Correlation Analysis of Personal Coordination Test and Cross Run 3 m-Cross Run Speed

1-3. Discussion

The Effect of Coordination and Anaerobic Loading on Judo Competition and Basic Techniques

The results of this study demonstrated a significant increase in heart rate following both judo-specific tests (Figures 4-5). The UKSN test involved three consecutive 10-second seoi-nage combinations, with only a 30-second rest period between sets. Similarly, the judo competition test also consisted of three 10-second seoi-nage combinations with a 30-second rest period between sets. Both tests were conducted in a 90-second simulated competition mode, characterized by high-intensity intermittent loads where rapid attacks were followed by short breaks.

This pattern of rapid muscle contractions induces anaerobic conditions within the muscles, leading to increased heart rate and cardiac output to supply more blood to the active muscle groups (Baechle & Earle, 2000). Consequently, both specialized tests elicited a significant increase in heart rate (Weils, 1957). Weils (1957) classified exercise intensity based on heart rate, with rates greater than 100 beats per minute (bpm) considered moderate, greater

than 140 bpm moderate intensity, greater than 160 bpm vigorous intensity, and greater than 180 bpm exhaustive intensity.

The UKSN test indicated a moderate-intensity load, while the 90-second simulated competition test reached an exhaustive-intensity load (Figures 4-5). These findings suggest that judo is a high-intensity sport, and athletes lacking optimal circulatory efficiency may experience early fatigue, thereby affecting their performance continuity.

Moreover, the heart rate during the 90-second simulated competition was positively correlated with the heart rate observed during a 150-meter sprint (Figure 4-6). The 150-meter sprint is a prototypical anaerobic load, with heart rates reaching exhaustion intensity by the end of the exercise. The study's results indicate a similarity between judo-specific loading and the anaerobic demands of a 150-meter sprint, establishing a positive correlation between the two. High heart rates during anaerobic loading, whether in running or judo, may reflect poor circulatory efficiency, leading to fatigue and reduced performance during competition. Conversely, subjects with lower heart rates during the 150-meter sprint and specialized judo tests likely possess better circulatory systems, avoiding excessive cardiac stress during anaerobic activities.

No correlation was found between crisscross running and UKSN heart rates, corroborating Capiteca Lam's (2010) findings, which showed no correlation between blood lactate levels in crisscross running and UKSN tests. This suggests that the load patterns of crisscross running and UKSN are different, despite both involving rapid muscle actions over 10 seconds.

The distinct nature of judo, involving physical close-quarters combat and opponent resistance, contrasts with crisscross running, which entails rapid sprinting and direction changes without external resistance. This difference likely explains the lack of correlation between the crisscross running load and judo-specific demands.

Table (06) : Comprehensive Analysis of Four Basic Abilities and Judo Specialization

Area	Judo Specialization Test Attack Frequency vs. 150m Speed Relationship	UKSN Test Frequency vs. Crisscross Run Speed Relationship	UKSN Test Frequency vs. Coordination Test Speed Relationship	Individual Coordination Test vs. Crisscross Run Speed Relationship (A best, D worst)
A	**5-6**	**2-8**	**1-2-8**	**4**
B	**3**	**1-3-5**	**3-7**	**3- 5**
C	**1-8**	**4-7**	**5-6**	**2- 7- 8**
D	**2-4-7**	**6**	**4**	**1- 6**

This table provides a comprehensive analysis of the relationships between various test frequencies and speeds in the context of judo performance.

Subjects 2, 4, and 8 consistently performed in the top proficiency block across multiple tests, while subjects 3, 1, and 7 excelled in only one test. Conversely, subjects 1, 8, 6, 4, 3, and 5 were found in the least proficient block for at least one test. This indicates that most athletes have areas of deficiency that require improvement.

In terms of judo movement patterns, it is crucial for athletes to quickly change the direction of their body or parts thereof in response to an opponent's attack, maintain balance while moving, and execute counter-throws or disrupt the opponent's balance to defend against or follow up on an attack. Tabata (1997) highlighted that judo involves high-intensity power output over 15 to 30 seconds, with each burst allowing the opponent to either defend or counter-attack. There is typically a 10 to 15-second rest period between these power outputs, constituting a high-intensity intermittent load. If the intervals are too short or recovery capacity is inadequate, the ATP-CP energy system cannot fully recover, necessitating anaerobic glycolysis for energy.

Degoutte et al. (2003) found that blood lactate levels in judo players rise to 12.3 mmol/L three minutes after competition, underscoring the intense anaerobic demands of the sport. Improving recovery capacity and anaerobic efficiency is therefore critical for judo athletes to maintain high performance throughout competitions.

Degoutte et al. (2003) reported that three minutes after the conclusion of a judo competition, athletes exhibited a significant increase in blood lactate levels, reaching 12.3

mmol/L. This underscores the essential need for judo athletes to possess not only speed and coordination but also strong anaerobic capacity to execute fast, precise, and stable movements during competitions.

Subjects #2 and #8 emerged as the top performers in this study. Subject #2 demonstrated strong performance in the 150-meter anaerobic load test, UKSN attack frequency, and cross running speed and coordination tests. However, their attack frequency in the 90-second simulation match was lower, attributed to adopting a strategic approach emphasizing timing over frequency. Subject #8 performed well across multiple tests but exhibited slower performance in the 150-meter anaerobic load and specialized attack frequency tests, alongside a lower attack frequency.

The lower endurance capacity of Subject #8 was posited as a contributing factor to their challenge in maintaining rapid attack frequencies in judo. Similarly, Subject #1 showed deficiencies in endurance and specialized attack frequency, alongside slower cross running speed, highlighting the need for improvements in both endurance and agility.

In summary, utilizing the four-limit analysis model allows for a comprehensive assessment of the strengths and weaknesses in both basic and specialized abilities among all subjects. Athletes with poor coordination amidst otherwise strong abilities should prioritize coordination training. Conversely, those with proficiency in only one area while lacking in others should focus training efforts on enhancing their weaker skills to achieve overall improvement.

Conclusion

Conclusion

The findings from this study highlight several important correlations that can enhance the understanding and training of judo athletes. Firstly, there is a notable relationship observed between the 90-second simulated judo match mode and the maximum anaerobic heart rate during the 150-meter sprint. This suggests that an athlete's performance in the 150-meter sprint can serve as an indicator of their anaerobic capacity and readiness for competitive judo.

Furthermore, the study reveals a significant correlation between the UKSN judo technique and the heart rate observed during coordination tests. This correlation underscores the impact of coordination on the consistency and effectiveness of judo techniques. Athletes with better coordination may demonstrate more consistent and efficient execution of techniques during matches.

It is recommended that future training programs utilize a comprehensive four-quadrant analysis of both basic and specialized abilities. This approach allows coaches and trainers to identify specific strengths and weaknesses in athletes' athletic abilities. By focusing on improving anaerobic capacity and addressing coordination deficiencies during preparatory training phases, athletes can enhance their foundational skills and optimize their performance capabilities for competitive judo.

Moreover, integrating this method of physical fitness and competition ability analysis across all stages of training—preparation, specialization, and competition—can provide a structured framework for continuous improvement. Coaches can tailor training regimens to target specific areas identified through analysis, thereby fostering holistic athletic development and maximizing athletes' potential in competitive environments.

In conclusion, leveraging correlations identified in this study, particularly regarding anaerobic capacity and coordination in judo, can inform targeted training strategies aimed at enhancing athletes' overall performance and competitive readiness. This approach not only supports athletic progression but also contributes to the ongoing refinement of training methodologies within judo and potentially across other sports disciplines.

The references

1. **Achten, J., & Jeukendrup, A. E. (2003)** explored maximal fat oxidation during exercise among trained men, emphasizing metabolic responses to exercise intensity.
2. **Arts, F.J.P., & Kuipers, H. (1994)** investigated the relationship between power output, oxygen uptake, and heart rate in male athletes, focusing on physiological responses during exercise.
3. **Böhmer et al. (2000)** provided insights into strength training and conditioning essentials, detailing methodologies for optimizing athletic performance.
4. **Coyle, E. F., & Gonzalez-Alonso, J. G. (2001)** discussed cardiovascular drift during prolonged exercise, offering new perspectives on cardiovascular responses during endurance activities.
5. **Degoutte, F., Jouanel, P., & Filaire, E. (2003)** studied energy demands during judo matches, highlighting the physiological stresses and recovery requirements in competitive judo.
6. **Task Force of the European Society of Cardiology and the North American Society of pacing and Electrophysiology (1996)** standardized heart rate variability measurements and their clinical implications, contributing to the understanding of autonomic nervous system function.
7. **Tabata (1997)** examined the metabolic profile of high-intensity exercises, establishing protocols for maximizing metabolic benefits in training regimes.
8. **Takahashi, R. (1992)** focused on power training in judo, detailing methods such as plyometric exercises with medicine balls to enhance explosive strength in judo athletes.
9. **Ronnie, L., Melnik, Y., Bilkevitz, A., & Falk, B. (2006)** introduced the Ten-Station Judo Ability Test, evaluating both physical and skill components crucial for judo performance.
10. **Wells et al. (1957)** proposed standards for lactic acid accumulation during exercise, which are foundational in categorizing and understanding exercise intensity and workload.
11. **Wood, R.H., Hondzinski, J.M., Lee, C.M. (2003)** explored age-related changes in physical, psychomotor, and autonomic functions, providing insights into aging and exercise physiology.